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The Financial Impact of the Use of Magnification Loupes on Registered Dental Hygienists and Dental Practices

LaTanya Nicole Hicks
Medical University of South Carolina

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LaTanya Nikole Hicks

A doctoral project submitted to the faculty of the Medical University of South Carolina in partial fulfillment of the requirements for the degree Doctor of Health Administration in the College of Health Professions

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Approved by:

Chair, Project Committee	Kit Simpson, Dr. PH	Date 5/1/17
Member, Project Committee	Charles Crosby, DDS	Date 4/17/2017
Member, Project Committee	Gwyndolan Swain, DHA	Date 4/17/2017
Dean, College of Health Professions	James S Zoller, PhD	Date 6/5/17

ABSTRACT

Abstract of Doctoral Project Presented to the Executive Doctoral Program in Health Administration & Leadership Medical University of South Carolina in Partial Fulfillment of the Requirements for the Degree of Doctor of Health Administration

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The purpose of this research is to identify the financial impact magnification loupes have on Registered Dental Hygienists (RDH) and dental practices. The aspects explored are RDHs who develop musculoskeletal disorders (MSD), and the cost difference to dental practices and RDHs when magnification loupes are used. A Markov Model was used to explore the cost differences. This research highlights the importance of implementing magnification loupes early in a RDH's career and the cost saving benefits this implementation has on RDHs and dental practices.

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Chapter 1

Introduction

A. Background and Need

Registered Dental Hygienists (RDH) are essential members of modern dental practices, and contribute greatly to the financial health of the practice (Lazar, 2012). However, musculoskeletal disease/disorder (MSD) is a growing problem within the dental profession (Liss et al, 1995). Poor ergonomics, long clinical hours, and repetitive motion causes MSD to be an ongoing issue (Liss et al, 1995). Many dental hygienists end up either leaving the profession and/or reduce their work hours due to MSD (Shah et al, 2006). Although, the repetitive motion of dental hygiene is an occupational hazard, much of MSD can be prevented by the use of magnification loupes (ML, loupes) (Sunell et al, 2003). Magnification loupes can help alleviate hand/wrist strain as well as postural discomfort and chronic muscular strain (Sunell, et al, 2003). The use of magnification loupes is not a panacea for MSD, because users must be inappropriately fitted and trained to use the loupes, for these to work. However, if magnification loupe use is mandated within the second semester of dental hygiene schools, it will be integrated into the students' expectation of practice. This change in the profession could lead to generally reduced risk of MSD sick days and potentially profound change the longevity of the career of dental hygienists.

This change in practice could benefit both the RDH and dental practices. Missed work or sick leave used within the dental hygiene department due to MSD, greatly affects the overall productivity of a dental practice. Based upon an office's fee structure, a hygiene department can add $1800-$2500/per hygienist in daily production (Doherty,

2009). A registered dental hygienist who is working while injured or missing work due to MSD; can have severe consequences on a dental practice's overall productivity and the quality of patient care. Not only is reducing hours or missing work in the hygiene department detrimental to a dental practice, it also causes a personal financial strain on the dental hygienist. However, the impact of MSD prevention is not well known.

The objective of this study is to estimate the expected financial impact on RDHs and on dental practices using a set of case study example to integrate information from the literature into estimates that can be used to inform discussions about requiring the use of looks in RDH training.

We will construct two financial estimating models to estimate:

1) Cost of ML purchase to a student and the expected cost avoided over a 20 year time horizon after graduation; and

2) Cost to a dental practice of purchasing and fitting MLs for a RDH and cost of sick days and potential practice disruption due to RDH turnover and/or reduced productivity avoided due to ML use by the RDH.

The proposed financial estimating models will use diverse sources of data on cost of MLs, prevalence of preventable MSD in RDHs, frequency of absences and other effects and cost of MSD and estimates of prevention of absences or turnover of RDHs in the practice setting. These effects have been well documented in separate reports, but the data has not been integrated into estimates that can inform discussions of change in practice. Some key points that will be embedded in the models are effects of magnification loupes, sick days due to MSD, and effects of RDH absences on practice, as discussed briefly below.

The use of magnification loupes by dental hygienists has been shown to reduce/decrease MSD, especially in the neck and back, by allowing greater visibility with no musculoskeletal risks (Pollack, 1996). Absences among dental hygienist in relation to MSD is prevalent, with nearly 14.6% (Pollack, 1996)-23.5% dental hygienists missing work due to MSD (Chismark, 2011). According to the US Bureau of Labor Statistics, as of May 2015, the national average pay rate for dental hygienists is $35-37/ hour. Effectively and efficiently using a dental hygienist can yield more than 50% of a dentist's production (Lazar, 2012). Therefore, loss of productivity caused by dental hygienists who are on leave or off of work due to MSD can be detrimental to a dental practice.

The direct costs of MSD have a significant financial impact on dental practices and registered dental hygienists. Many registered dental hygienists who have been afflicted with MSD must decrease the number of days they work or leave the profession due to their musculoskeletal pain (Chismark et al, 2011). One study stated 31% of dental hygienists reported working fewer hours due to MSD, with 14.6 % missing work due to MSD (Yee et al, 2005). Another study stated that as a result of MSD, dental hygienists took a median of 5 sick days, as opposed to 2 sick days by those who have not experienced any MSD (Petren, 2007), with another study showing that subjects working with their neck bent > 20 degrees for more than 40% of work time were at greater risk for sickness absence exceeding three days due to MSD (Hannson, 2004). A more recent study stated that 23.5% of dental hygienists called in sick or missed work as a result of chronic musculoskeletal pain (Chismark, 2011).

Employing registered dental hygienists within a practice greatly increases output per dentist and net income (Levin, 2010). It has been shown that a 10% increase in

registered dental hygienists hours would increase dental output per hour by 2.74% (Beazoglou, 2012). An effective and efficient hygiene department can secure more than 50% of a doctor's production (Levin. 2003). Registered Dental Hygienists do more than just "clean teeth" and can be the backbone of a dental practice, which is why it is imperative to decrease the number of sick days due to MSD within the hygiene department.

A. National Statistics & Trends

MSD is prevalent among dental hygienist, with one study stating that 93% of dental hygienist reported at least one musculoskeletal disorder (Yee, 2005). MSD has a negative impact on work and productivity, because it can cause a dental hygienist to miss work, therefore decreasing productivity. Productivity is reflected by reduced working hours with 27.8% of dental hygienists reported reducing their work hours due to occupationally related musculoskeletal pain (Yee, 2007). There is not a catholicon for MSD in the dental profession, but research shows that improving posture and ergonomics with the utilization of magnification loupes can decrease the onset of MSD (Maillet, 2008), (Thomas, 2007).

B. Statement of the Problem

A review of the literature indicates that MSD is a growing problem within the dental profession. Poor ergonomics, long clinical hours, and repetitive motion causes MSD to be an ongoing issue. Many dental hygienists either leaving the profession and/or reduce their work hours due to MSD. Although, the repetitive motion of dental hygiene is

an occupational hazard, magnification loupes can help alleviate hand/wrist strain as well as postural discomfort. The use of magnification loupes is not a panacea for MSD, but if mandated within the second semester of dental hygiene schools, it could lead to reduced sick days and profound longevity of a dental hygienist's career.

Missed work or sick leave within the dental hygiene department due to MSD, greatly affects the overall productivity of a dental practice. Based upon an office's fee structure, a hygiene department can add $1800-$2500/per hygienist in daily production (Doherty, 2009). A dental hygienist who is working while injured, or missing work due to MSD; can have inimical consequences on a dental practice's overall productivity and patient care. Not only is reducing hours or missing work in the hygiene department detrimental to a dental practice, it also causes a personal financial strain on the dental hygienist.

Mandating magnification loupes within the dental hygiene curriculum; where there is adequate time for the adjustment period, ergonomic modifications and to have the magnification loupes fitted properly, can greatly improve posture (Maillet, 2008); therefore, potentially improving MSD (Hayes, 2013) and increasing the longevity of a student's dental hygiene career.

C. Research Aim

This study will examine the cost effectiveness of mandating the use of magnification loupes by dental hygiene students compared to ad hoc use of magnification loupes by registered dental hygienists. The purpose of this study is to determine the financial impact on dental practices of mandating magnification loupes in dental hygiene

schools to reduce future MSD among registered dental hygienist.

D. Significance of the Study

The use of magnification loupes by dental hygienists has been shown to decrease adverse effects of postural discomfort associated with professional practice. A number of dental hygiene programs strongly suggest that their students use magnification loupes. However, the expense and adjustment period of the magnification device seem to be a deterrent amongst students, as well as students not fully understanding the ergonomical benefit of wearing magnification loupes. Furthermore, dental hygienists who were not accustomed to working with magnification loupes during their education may poorly adhere to the use of magnification loupes in private practice, even if the dental practice provide and/or encourage the use of loupes. It may be important to inoculate loupe use in professional practice during hygiene education.

Many studies have focused on the correlation between ergonomics, MSD, sick leave and magnification loupes. This study will add to the bodies of knowledge by using a decision analysis model populated with data from the literature to examine the cost effectiveness of mandated vs. voluntary magnification loupe use.

E. Research Question

Is there a financial impact on RDHs and dental practices when implementing magnification loupes during a RDH's training as opposed to not utilizing loupes at all?

Hypotheses

Is there a measurable difference in financial impact based on:

a) The amount of RDHs who develop MSD and progress through the state of leaving the profession with and without MLs use.
b) The cost of magnification loupe purchased by a student and the exposed cost avoided over a 20 year time horizon after graduation.
c) The cost to a dental practice for purchasing and fitting magnification loupes for a RDH and cost of sick days and potential practice disruption due to RDH turnover and or reduced productivity avoided due to loupe use by a RDH.

F. Definition of Terms

Musculoskeletal Disorder/Disease (MSD): Injuries, disorders or diseases that affect the body's movement or musculoskeletal system.

Registered Dental Hygienist (RDH): Licensed oral health professionals who focus on preventing and treating oral diseases-both to protect teeth and gums, and also to protect patient's total health

Magnification loupes (ML): A simple magnification device used to see small details more closely. Dental magnification loupes feature "through the lens" (TTL) magnification or "flip-up" magnification and may/may not have a loupe light mounted on the bridge of the loupes with side shields.

Worker's Compensation (WC): A form of insurance providing wage replacement and medical benefits to employees injured in the course of employment.

Quality-adjusted-life-year (QALY): A generic measure of disease burden, including both the quality and quantity of life lived. Used to assess the value of money of medical interventions

Chapter 2

Review of the Literature

A review of the literature indicates that there has been a considerable amount of research conducted on musculoskeletal disorders (MSDs), within the dental workforce, as well as ways to remedy MSDs; whether it is ergonomics and/or magnification loupe. MSDs are considered a significant occupational health issue for dental practitioners (Hayes et al, 2011). MSDs complications can lead to sick leave, reduced productivity and early retirement. When looking at productivity, the literature addresses several issues, including withdrawal or reduced hours from the dental hygiene workforce due to MSDs, and the factors that contribute to and/or prevent its occurrence.

A. Musculoskeletal Disorders (MSDs)

Work related tasks are considered to be the causative agent leading to MSDs with the dental profession, due to repetitive scaling and awkward positioning (Hayes et al, 2011). Hayes et al discussed the ramifications of MSDS and risks factors to predict MSDs among Australian dental hygienists. The study, which consisted of 624 Australian dental hygienists, and utilized a five-page modified version of the Standardized Nordic Questionnaire, was administered to the dental hygienists (Hayes et al, 2011). The questionnaire consisted of self-reported questions in regards to musculoskeletal symptoms/pain over the duration of 12 months, if noted pain lasted longer than 2 days, and if the musculoskeletal issues impacted their daily life and/or needed medical attention; the questionnaire included an anatomical diagram to assists the participants in answering the questions pertaining to musculoskeletal pain (Hayes et al, 2011). The study

found that two-thirds of the participants experienced neck, shoulder and back pain, with pain lasting more than two days, and half of the participants stated the pain affected their daily life (Hayes at el, 2011).

Fish et al, discussed the MSDs related to the practice of dentistry. This qualitative study attributed lower back pain from the twisting or rotating of the trunk during forward/spinal flexion, which may stretch extensor muscles of the back and posterior ligaments. (Fish et al, 1998). During this forward flexion motion, the facet joints are also stressed which open the articular surfaces, thus making the facet joints less stable (Fish et al, 2011). Prolonged opening of the facet joints may cause inflammation leading to the joints inability to close properly when the trunk returns to an upright position. (Fish et al, 2011). The opening and closing of the joints provides lubrication and nutrition to the joint surfaces, but habitual spinal flexion reduces the lubrication causing degenerative changes in the cartilage and/or intervertebral disc changes (Fish et al, 2011). The risk factors for MSDs in in direct correlation to the work habits involved with dental professionals.

Guignon et al conducted a twenty-two closed-ended questions survey to determine the prevalence and type of work-related musculoskeletal disorders (WRMSD) and injuries among dental hygiene practitioners. One thousand two hundred and seventeen surveys were completed, and the results revealed 51% reported one or more WRMSD and the top three primary pain sites were: 63% neck, 54.2% shoulder, and 35.8% lower back (Guignon et al, 2014). As the longevity of a clinician increases, so does the prevalence of WRMSD. The study shows that clinicians with less than one year of practice, 13% have experienced neck pain, 18% shoulder pain and 8% lower back pain; clinicians with one to ten years of practice, 33% experienced neck pain, 27%

shoulder pain and 19% lower back pain (Guignon et al, 2014). This study also reported that 38% of clinicians with WRMSD reduced their clinical hours permanently and 27% reduced their clinical hours temporary. (Guignon et al, 2014).

B. Missed days from work/reduced hours

Due to WRMSDs many dental professional are forced to either reduced hours at work, miss days at work or are forced into early retirement (Petren et al, 2007). Petren et al preformed a study correlating sick leave and MSDs among Swedish dental hygienist. Four hundred and eleven dental hygienists responded to a self-reporting 300-item questionnaire on working environments, which included MSDs, and a homogenous group of 252 was randomly selected out of the 411 respondents (Petren et al, 2007). The subjects were then classified in groups: musculoskeletal disorders (MSD), low well-being (LWB), both low well-being and musculoskeletal disorders (BLM) and relative health/main group (M group). The results of the study show sick leave (days absent from work due to sickness in the last 12 months) was significantly higher in the MSD group (21) compared to the M group (6), and the MSD group had significantly more clinical work hours (34/week) and treated more patients per day (11) compared to the other groups, which indicates a correlation between patient volume (patients treated per day), in-patient care clinical hours and MSD (Petren et al, 2007). The study showed weak support that MSDs caused by scaling work influenced sick leave, although it is a common health problem (Petren et al, 2007). The study also speculates that dental hygienists with MSD may not take sick leave or miss work despite the pain, because their duties cannot be easily handed over to another dental professional. (Petren et al, 2007).

Hayes et al also reported on the workforce impact of MSDs on dental hygienists. Dental hygienist reporting neck pain were more likely to have time off from work (odds ratio (OR): 2.4) or to consider reducing clinical work hours (OR: 6.65) than those without neck pain. Those reporting lower back pain were also more likely to report time off from work than their health counterparts (OR: 2.11) and were also more likely to be considering alternate careers (OR: 2.18).

A study that focused on one the year prevalence of self-reported musculoskeletal discomfort in the neck, shoulder and lower back areas among dentists in South Africa, showed a correlation between MSD and missed work (Botha et al, 2014). An anonymous, web-based, analytical cross sectional study using Nordic Musculoskeletal Questionnaires and incorporated forced choice variant questions, was emailed to all 3112 members of the South African Dental Association, with 338 replies; a response rate of 10.9% (Botha et al, 2014). The study reported that the one year prevalence for MSDs is: neck =77.9%, shoulder =72.4% and lower back= 69.8%, and both men and women experienced high prevalence rates for neck, shoulder and lower back troubles. (Botha et al, 2007). Missed days from work from MSD was prevalent, showing that many respondents took 8-30 days off due to MSD complications (6.5% for lower back, 5.5% for neck and 4.1% for shoulder) and some respondents taking off more than 30 days over the one year period (Botha et al, 2014). The study showed the musculoskeletal discomfort/trouble is prevalent within the dental profession and is attributed to common working behaviors such as torso twists, tipped shoulders, elbow raised during operation (Botha et al, 2014).

Lotters et al conducted a study on sickness absence due to MSD. The study was a longitudinal study with a 12-month follow-up in which a self-administered questionnaire

(consisting of the Dutch Musculoskeletal Questionnaire for work-related physical factors such as manual material handling, frequent bending twisting of the trunk, working in awkward positions, working in static postures, and strenuous work with neck/shoulder and upper limb, and a modified Nordic Questionnaire for nature and severity of complaints) was used to measure prognostic factors for sickness absence, and included workers who were on sickness absences for 2-6 weeks due to nonspecific MSD (Lotters et al, 2006). The patients were enrolled in the study by occupational health physicians during their consults or selected from the absenteeism register from a large Dutch occupational health service (Lotters et al, 2006). The occupational physicians included 140 patients, and 307 patients were selected from the administration of absenteeism (in which only 59% of the 307 agreed to participate). Only 287 of the 321 patients returned the questionnaire, but only 253 patients could be used (Lotters et al, 2006). Of the 253 patients, the data shows that the top three causes for sickness absence were: 51% due to lower back pain and absent 101 days, 17% due to shoulder pain and absent 98 days, and 11% due to neck pain and absent 79 days. (Lotters et al, 2006).

Yee et al conducted a study to evaluate how MSDs and workplace psychosocial factors affected dental hygienists' work hours and productivity. A 158-item questionnaire (consisting of questions from the modified Nordic Musculoskeletal Questionnaire) was mailed out to dental hygienists in the Los Angeles and Orange Counties areas, in which 529 questionnaires were returned (37.3% response rate) (Yee et al, 2005). Reduction in work hours was common (46.9%), and musculoskeletal discomfort cited by 27.2% as a cause of reduced work hours with 16.4% reducing hours due to neck pain, 16% reducing hours due to shoulder pain and 12.1% reducing hours due to lower back pain. 27.8%

missed at least 2 full days of work over the course of 5 years, with the cause being: musculoskeletal discomfort (14.6%) with hand (7%) and lower back pain (7%) being the most common reasons, followed by neck (5.7%) and shoulder (5.5%).

In a prospective cohort study conducted by Andersen et al, 5603 employees in Denmark from were telephone interviewed and then followed in a national sickness absence register for 1 year. The study shows that pain in the neck/shoulder, lower back, knees and hand/wrists was 33%, 33%, 16% and 16% in blue-collar workers and 29%, 25%, 12% and 11% in white-collar workers, with 18% blue-collar and 12% white-collar workers developing long-term sickness absence (Andersen et al, 2010).

A study conducted by Basile et al explored prevalence and reasons for withdrawal from the dental hygiene workforce. A questionnaire consisting of 45 open-ended and closed-ended questions was to 2672 dental hygienists licensed in Minnesota, of that 2672, 1420 responded with only 129 indicating they were no longer currently working, but still held an active license (Basile et al, 2007). The study found that the primary reason for permanently leaving the workforce was because: child-rearing responsibilities (30%), pursuing a different career (29%), health reasons (26%), and retired. Individuals who left the workforce temporarily did so because: child-rearing responsibilities, health reasons (17%), pursuing a different career (10%) and retired (0%) (Basile et al, 2007).

C. Productivity

Beazoglou et al conducted a study examining the impact of expanded function allied dental personnel on the productivity and efficiency of general dental practices. 164 general practices located in Colorado participated in the study (only 154 practices were

utilized), by completing a survey questionnaire about practice operations and delegations of duties (Beazoglou et al, 2012). The study shows that 63.6% of practices utilized expanded function allied dental personnel to complete reversible procedures; by delegating dental hygienists and dental assistants to complete reversible procedures, it freezes up the dentists to complete more complicated procedures thus generating higher gross billings and net incomes (Beazoglou et al, 2012). Practices that utilized allied dental personnel had a gross billing of $1,006,487 and net income of $326,311 opposed to practices that did not utilize allied dental personnel had a gross billing of $602,990 and net income of $209,825 (Beazoglou et al, 2012).

Effectively utilizing RDHs within a practice can lead to more than 50% of a dentist's production (Lazar et al, 2012). A study conducted by Lazar and colleagues explores the differences among dental practices that operate with and without RDHs. This study utilized the 2003 Survey of Dental Practices (SDP), conducted by the Survey Center of the American Dental Association (ADA), which is sent out to a randomly selected group of dentists in private practice, ADA members and nonmembers resulting in 854 practices being selected for this study (Lazar et al, 2012). 60.6% of practices employ one or more RDHs, and those practices that do employ RDHs have an annual net income of $56,102 (31%) greater and an annual gross billing balance of $231,134 (41%) greater than those that do not employ RDHs (Lazar et al, 2012). The study supports the findings that employing dental hygienists add greater production and larger gross and net incomes to the practice.

Profitability within the dental hygiene department is in direct correlation to billable services provided (Doherty, 2009). Doherty et al wrote an article about the

profitability of an efficient and effective hygiene department, and taking a losing hygiene department from daily production of $600 to $800 to a winning department obtaining a daily production of $1500 to $2500. Practices should strive to generate at least 25% of their income from hygiene services, and an effective and efficient hygiene department will identify and help secure more than 50% of a doctor's production by focusing on oral health promotion, disease prevention and comprehensive care (Doherty, 2009).

The common goal of all dental practices is to achieve maximum production and profitability while providing extraordinary patient care (Levin, 2004). Roger Levin wrote an article discussing the driving force behind dental practices and correlating it with hygiene productivity. Levin stated that in order to double or triple hygiene production, a hygiene department must implement a periodontal therapy protocol, periodontal antibiotics, esthetic/whitening procedures, sealant protocol, oral cancer exams and an improved scheduling/recall system (Levin, 2003). The aforementioned implementations will maximize hygiene department performance resulting in higher productivity and profitability (Levin, 2003).

The Bureau of Labor Statistics showed in May 2015, that there were 200,550 dental hygienist jobs in the United States with approximately 174,100 practicing RDHs. The average hourly rate is $34.96 and average annual wage is $72, 720. There are 151,500 dentist jobs in the United States with approximately 190,000 practicing dentists. The average hourly rate is $76.11 and the average annual wage is $158,310 (BLS, 2015). The average weekly hours for both dentists and dental hygienists is 32-40 hours a week for full time clinicians (BLS, 2015).

D. Ergonomics

Ergonomics studies human stress and strain related to activities, and the premise behind the science of ergonomics is to prevent work related musculoskeletal disorders, or symptoms that aggravate these disorders (Pollack, 1996). In a qualitative study, Pollack addresses the poor working habits, along with the repetitive movements that contribute to MSDs and states the key objective is to find a position that allows clinicians to achieve optimum access, visibility, comfort and control at all times (Pollack, 1996). The study goes on to state that while in patient care, the clinicians muscles should all be relaxed except for the ones performing the task; and the goal is to have optimal visibility, because when visibility is blocked, posture is compromised by leaning, twisting or taking on awkward postures (Pollack, 1996). Dental scopes/magnification loupes facilitate the need for the clinician to get closer to the treatment site without compromising posture (Pollack, 1996).

Chismark et al conducted a study to determine if dental hygienists who have chronic musculoskeletal pain (CMSP) and use complementary and alternative medicine (CAM) therapies have better career satisfaction compared to conventional therapy (CT). A total of 2,431 surveys were electronically sent out to American Dental Hygiene Association (ADHA) members; 573 in North Carolina and 1,858 in California (Chismark et al, 2011). A total of 76.5% respondents reported having CMSP with a mean duration of pain of 6.1 years, and 23.5% respondents reported missing work or calling in sick due to their chronic pain (Chismark et al, 2011). RDHs who suffered from CMSP reported that it had a negative impact on career longevity, with 36.4% considering a career change and 13% leaving the dental hygiene profession (Chismark et al, 2011). Since musculoskeletal

pain is associated with work stress and burnout among dental hygienists, CAM therapies may reduce work interruptions caused by musculoskeletal pain, resulting in a higher career satisfaction and longevity (Chismark et al, 2011). The most favored CAM therapies are: non-vitamin/non-mineral natural products (17.7%), deep breathing exercises (12.7%), meditation (9.4%), chiropractic care (8.6%) massage (8.3%) and yoga (6.1%) (Chismark et al, 2011). The study shows that CAM therapies in conjunction with proper ergonomic equipment such as magnification loupes can reduce WRMD and CMSP and should be further investigated (Chismark et al, 2011).

An investigation by Beach et al, was conducted to determine the existence and extent of ergonomic education in dental hygiene curriculum in order to prevent MSDs (1998). A 30-question survey consisting of questions pertaining to who taught ergonomic principles and characteristics of basic and additional ergonomic education, was mailed to program directors of all accredited dental hygiene programs in the United States (n=216) with n=168 responding (Beach et al, 1998). Ninety-eight percent of the programs stated their curriculum included ergonomic education with 52.7% of the programs offering <1 hour of additional ergonomic education and only 5.5% of the programs offering >10 hours (Beach et al, 1998).

E. Magnification Loupes

Rucker et al conducted a study to analyze the risk factors associated with dentists developing musculoskeletal problems (2002). Data was analyzed from surveys received from 421 dentists from, British Columbia, who had graduated between the years of 1987 and 1996; . The survey consisted of open and closed-ended questions asking respondents

about their practice ergonomics, practice management issues, lifestyle, perceived control of their work environment and specific musculoskeletal symptoms (Rucker et al, 2002). On a weekly basis 9% of the respondents experienced work-related hand pain, 18% experienced shoulder pain, 24% experienced neck pain, 19% experienced upper back pain, 13% experienced mid-back pain and 17% experienced lower back pain; 34% attributed their musculoskeletal symptoms entirely to their clinical work, with only 4% decreasing their working days per week due to symptoms (Rucker et al, 2002). That data shows that proper ergonomics and utilizing ergonomic equipment, such as magnification loupes (ML) can decrease musculoskeletal pain; the use of MLs is associated with a decrease of pain in the lower back (p=34) (Rucker et al, 2002).

There is a statistically significant relationship between equipment, posture, positioning and psychosocial variables, and the incidence of musculoskeletal problems (Sunell et al, 2003). A study conducted by Sunell et al, analyzed data from 170 survey respondents from British Columbia indicate that dental hygienists are experiencing musculoskeletal discomfort/pain that is attributed to their clinical work (2003). A questionnaire to find out more about dental clinicians health status and work profile, was sent out to 433 dental hygienists and 975 dentists in British Columbia. A total of 170 responses were received from the dental hygienists and 421 responses from the dentists. Eighty-six percent of dental hygienist indicated that they had experienced work-related problems within the past year; particularly they noted pain in the neck (80%), hands (75%), shoulders (71%), upper back (64%), and lower back (59%), and 94% stated that their musculoskeletal symptoms were either caused entirely or exacerbated by their clinical work (Sunell et al, 2003). Eighty-one percent of dental hygienists and 61% of

dentists reported utilizing a variety of strategies and therapies to alleviate their musculoskeletal discomfort; noting the most successful therapies were increased exercise (13%), change in clinical work habits/postures (6%) (Sunell et al, 2003). Ergonomic equipment such as adjustable head rest (46%), adjustable operating lights (86%) adjustable operating stools (79%) and MLs (6%) are huge assets in postural positioning (Sunell et al, 2003). The following patterns were associated with decreased risk of musculoskeletal symptoms: increased time with articulating head rest decreased upper back pain (p=.025), ability to utilize all clock positions decreased symptoms in the shoulders (p=.042), neck (p=.020) and upper back (p=.035), positioning legs under the chair more than 50% of the time decreased frequency of leg symptoms (p=.041), and the use of surgical magnification decreased lower back (p=<.001) (Sunell et al, 2003).

Branson et al conducted a study on the experience of a RDH student during a four week acclimatization period of using magnification loupes. Research has shown that when RDHs are in clinical care, 90% of the time their head is forward at angles ranging from 17 degrees-39 degrees, and 10% of the time, their head is forward at an angle greater than 40 degrees; thus many hygienists turn to MLs to decrease neck flexion and improve clarity of the work area (Branson et al, 2010). The case utilized a mixed-method design to study the changes in posture of a dental hygiene student acclimating to MLs, incorporating real time observation using the standardized Branson Posture Assessment Instrument (BPAI) to examine the posture prior to and while using magnification loupes, as well as self-reporting through reflective journaling to chronicle the acclimatization process (Branson et al, 2010). The study shows that the BAPI scores indicate that posture improved by 10 points when the RDH student was wearing MLs, specifically in forward

flexion of the head and shoulder protraction (Branson et al, 2003). Evidence suggests that using magnification loupes will improve the posture of dental clinicians, and this study proves the use of MLs improved posture for the RDH student (Branson et al, 2010).

F. Career and Profitability

Registered dental hygienists have played an integral role in promotion of oral health, wellness and disease prevention (Basile et al, 2007). The economic impact of registered dental hygienists on solo or group practices is immense, because they help expand dentists' service capacity by performing tasks delegated by the dentists (Lazar, 2012). It has been stated that the backbone of a dental office is a successful dental hygiene department (Doherty, 2009). The dental hygiene department can add up to $1500-$2500 per day/per hygienist in daily production (Doherty, 2009). The service fees on the chart below can differ from office to office depending upon location; for example a prophylaxis can range anywhere from $75-$95, but the chart is a great example on how lucrative the dental hygiene department can be (Lazaar, 2012). Dental hygienists increase production of the dental practice, therefore, increasing gross and net incomes of the dentists' (Lazaar, 2012). An effective and efficient hygiene department will help secure more than 50% of a dentist's production (Levin, 2003).

Chart. An Example of a Hygienist's Comprehensive Day Seeing 8 Adult Patients Per Day Using Sample-Fee Structures.
4 prophylaxis ($75 x 4) $300 2 periodontal maintenance ($105 x 2) $210 2 scaling and root planings ($180 x 2) $360 4 bite-wings (7- verticals) ($56 x 4) $224 1 panoramic film $78 1 periapical x-ray $14 1 Vizilite oral cancer screening $50 5 sites of ARESTIN ($30 x 5) $150 4 fluoride varnish treatments ($28 x 4) $112 2 desensitizing applications ($28 x 2) $56

(Doherty, 2009)

The profession of dental hygiene can be quite advantageous; especially for women, who account for 97.5% of dental hygienist (Petren et al, 2007). A minimum of a two year associate's degree is needed in order to practice dental hygiene in most States in the United States of America (Basile, 2007). According to the American Dental Hygienists' Association, the average estimated total cost (In-State/District) of tuition and fees for an associate degree is $22,692 ($36,382 for a baccalaureate degree) (www.adea.org, 2015). Upon completion of a dental hygiene degree and successfully passing national and clinical board exams; a registered dental hygienist can have an earning potential of $72,720 per year (www.bls.gov, 2015).

Chapter 3

Methods

The objective of this study was to estimate the expected financial impact on RDHs and dental practices using a set of case study example to integrate information from the literature into estimates that can be used to inform discussions about requiring the use of magnification loupes in RDH training.

We constructed two financial estimating models to estimate:

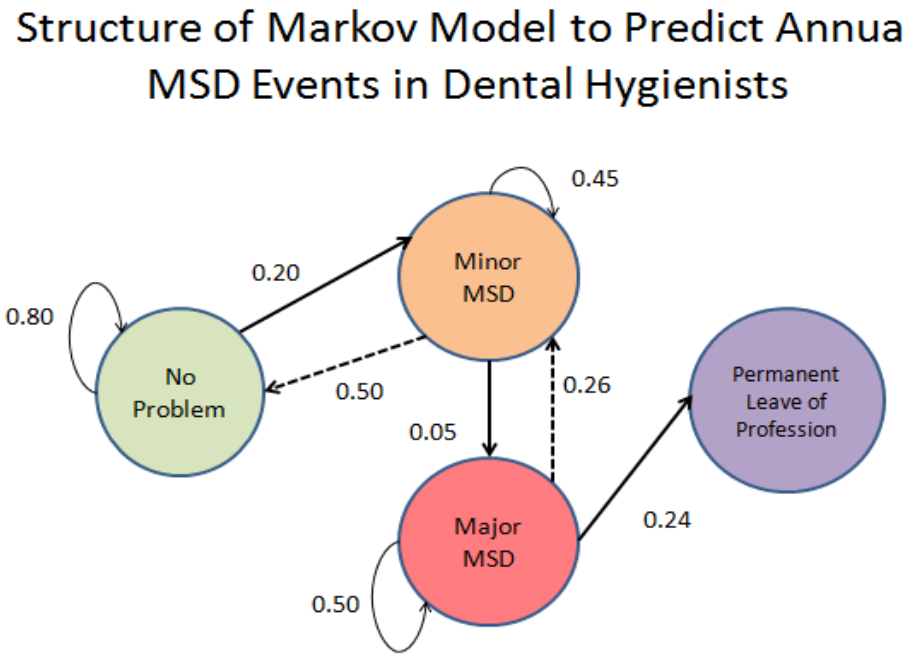
1) Cost of ML purchase to a student and the expected cost avoided over a 20 year time horizon after graduation; and

2) Cost to a dental practice of purchasing and fitting MLs for a RDH and cost of sick days and potential practice disruption due to RDH turnover and/or reduced productivity avoided due to ML use by the RDH.

The financial estimating models used diverse sources of data on cost of MLs, prevalence of preventable MSD in RDHs, frequency of absences and other effects and cost of MSD and estimates of prevention of absences or turnover of RDHs in the practice setting. These effects have been well documented in separate reports, but the data has not been integrated into estimates that can inform discussions of change in practice.

We used Markov Model to capture the impact of the use of MLs because a decision tree ended up having an unwieldy number of required branches if it was to capture changes over the time of the career of a RDH. The model has three transitions of health states; 1) No MSD problem; 2) Minor MSD; and 3) Major MSD; and a final absorbing health state which assumed the RDH leaves the profession. The Figure below shows the potential progression through the states of MSD over a 20 year time horizon.

The odds of progressing to MSD were extracted from reports in the literature, as was the data to calculate the progression from one state to the next. Where the literature was missing the data needed we made reasoned assumptions that can be tested in a sensitivity analysis. The base model assumes that out of 100 RDHs, 20% of them may develop a minor MSD problem, while 80% of those RDHs will remain problem free. Out of 100 RDHs in the minor category, 50% of them will be problem free while 45% present with minor issues and 5% progress to major problems. Amongst the 100 RDHs in the major category, 0% present with no problems, 26% present with minor problems, 50% present with major problems and 24% leave the profession. The model was implemented in Excel for ease of implementation. The iteration of this model is then used to estimate progression over time, with a time horizon of 20 years assumed in the study. The structure of the model is shown in the figure below.



Chapter 4

Results

This chapter provides the results derived after analyzing the data. This study was conducted to determine the financial impact that loupes have on the registered dental hygienist reporting musculoskeletal pain, and the dental practice, when introduced early in his/her career. A Markov Model was used to predict the financial effect of magnification loupes (MLs) in the prevention of musculoskeletal problems in dental hygienists.

A population size of 100 was used to assess the four states of musculoskeletal disorder a RDH may display during his/her career. The four states (variables) were: no problems, minor problems, major problems and leaving the dental hygiene profession. Data was extracted from the literature to show the effect of using loupes has on dental hygienists while in a particular state and/or preventing a RDH from progressing into a particular state and the financial effect of being in that state has on RDHs and the dental practices.

Hypothesis one: There will be an important difference in the estimated number of RDHs who develop MSD and progress to leaving the profession with and without MLs use.

A Markov Model was constructed to show the potential progression through the states of MSD over a 20 year time horizon. An odds ratio of 1.52 was extracted from the data to calculate the progression from one state to the next. Out of 100 RDHs, 20% of them may develop a minor MSD problem, while 80% of those RDHs will remain problem free. Out of 100 RDHs in the minor category, 50% of them will be problem free

while 45% present with minor issues and 5% progress to major problems. Amongst the 100 RDHs in the major category, 0% present with no problems, 26% present with minor problems, 50% present with major problems and 24% leave the profession. The model further shows the percentage of RDHs who were affected in each state for 20 years.

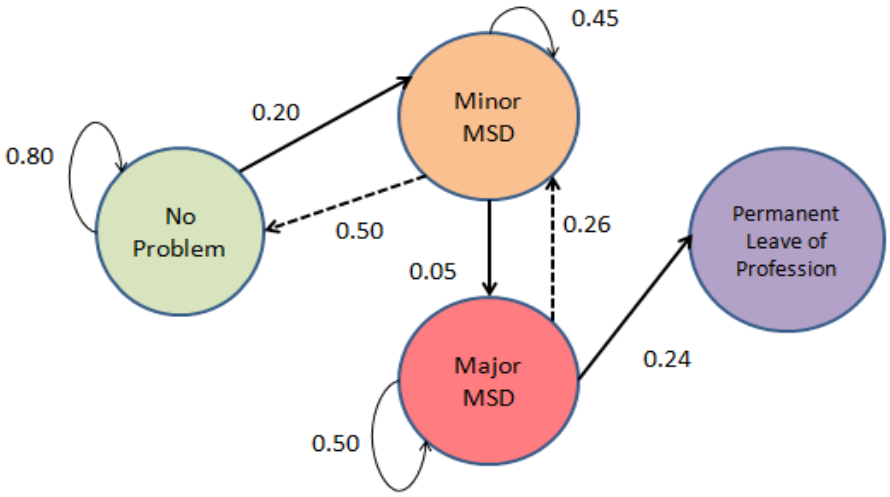
Base Model With Use of Loupes					
	No Problem	Minor	Major	Leaving DH	SUM
No Problem	0.80	0.20	0	0	1.00
Minor	0.50	0.45	0.05	0	1.00
Major	0	0.26	0.50	0.24	1.00
Leave DH	0	0	0	1.00	1.00
Year: Start Number	100				Check
1	80.0	20.0	0.00	0.00	100.00
2	74.0	25.0	1.00	0.00	100.00
3	71.7	26.3	1.75	0.24	100.00
4	70.5	26.6	2.19	0.66	100.00
5	69.7	26.7	2.43	1.19	100.00
6	69.1	26.6	2.55	1.77	100.00
7	68.6	26.4	2.60	2.38	100.00
8	68.1	26.3	2.62	3.00	100.00
9	67.6	26.1	2.63	3.63	100.00
10	67.2	26.0	2.62	4.26	100.00
11	66.7	25.8	2.61	4.89	100.00
12	66.3	25.6	2.59	5.52	100.00
13	65.8	25.5	2.58	6.14	100.00
14	65.4	25.3	2.56	6.76	100.00
15	65.0	25.1	2.55	7.37	100.00
16	64.5	25.0	2.53	7.99	100.00
17	64.1	24.8	2.51	8.59	100.00
18	63.7	24.6	2.50	9.20	100.00
19	63.3	24.5	2.48	9.79	100.00
20	62.8	24.3	2.46	10.39	100.00

Base Model Without Use of Loupes					
	No Problem	Minor	Major	Leaving DH	SUM
No Problem	0.70	0.30	0	0	1.00
Minor	0.50	0.45	0.05	0	1.00
Major	0	0.26	0.50	0.24	1.00
Leave DH	0	0	0	1.00	1.00
Year: Start Number	100				Check

1	69.6	30.4	0.00	0.00	100.00
2	63.6	34.8	1.52	0.00	100.00
3	61.7	35.4	2.5	0.4	100.00
4	60.7	35.4	3.02	0.97	100.00
5	59.9	35.1	3.28	1.69	100.00
6	59.3	34.9	3.40	2.48	100.00
7	58.7	34.6	3.44	3.29	100.00
8	58.1	34.3	3.45	4.12	100.00
9	57.6	34.0	3.44	4.95	100.00
10	57.1	33.7	3.42	5.77	100.00
11	56.6	33.4	3.40	6.59	100.00
12	56.1	33.1	3.37	7.41	100.00
13	55.6	32.8	3.34	8.22	100.00
14	55.1	32.5	3.31	9.02	100.00
15	54.6	32.3	3.28	9.81	100.00
16	54.2	32.0	3.26	10.60	100.00
17	53.7	31.7	3.23	11.38	100.00
18	53.2	31.4	3.20	12.16	100.00
19	52.8	31.2	3.17	12.92	100.00
20	52.3	30.9	3.14	13.69	100.00

A Markov Model transition diagram was also constructed to show the health states and the annual transitions between them. The model shows that in the first year, out of 100 RDHs, 20% of them will progress to a minor state, while 80% of them will stay in the no problem state. That following year, those same 80% may recycle back into the no problem state, or move into the minor state. Those that progress into the minor state, 45% may recycle year after year in the minor state, 50% may go back to a no problem state (with medical interventions i.e. exercising, rehab, etc.) or 5% may move into a major health state. That next year, there may be 50% in the major state and recycle in that state, with 26% moving back into a minor state and 24% leaving the dental hygiene profession.

Structure of Markov Model to Predict Annual MSD Events in Dental Hygienists



Hypothesis two: The cost of ML being purchased by a student will be largely offset by the expected cost avoided over a 20 year time horizon after graduation.

The initial cost of loupes is estimated around $1706, and one pair of loupes should be a one-time purchase with battery replacement cost of the light being $120 every three years. For the 20 year horizon, the total loupe cost will be $2506 per RDH. With a sample size of 100 RDHs, the total loupe cost per RDH over 20 years is $250,600. Per the Markov Model, the difference in cost between RDHs with loupes and without loupes is $6,183,856 with there being a significant cost savings amongst RDHs who utilize magnification loupes.

Cost of ML and battery Q 3 Yrs.	**2506**		
Results over 20 years	**Loupe**	**No Loupe**	**Difference**
Total Loup cost	$ 250,600		
Total Salary, WComp medical care	$ 19,087,676	$ 25,522,132	
Grand Total Cost	$ 19,338,276	$ 25,522,132	$ 6,183,856

Cost of no ML

Results over 20 years	Loupe
Total Cost	$ 25,522,132
Total Sick Days	3135.0
Total Leaving DH	13.69
Total Wcomp cases	1.25

Hypothesis three: The model will show that the cost to a dental practice of purchasing and fitting MLs for a RDH is largely offset by avoidance of the cost of sick days and potential practice disruption due to DH turnover and/or reduced productivity avoided due to ML use by a RDH.

The Markov Model shows days missed due to minor and major MSD problems and calculates the salary potentially lost due to sick days (minor and major), medical costs, worker's compensation, RDHs leaving the profession, and turnover. The RDH's QALY is also estimated.

Sick Days

The number of sick days missed due to a major and minor MSD issue over 20 years is 2389 days for RDHs who utilize MLs and 3135 days for RDHs who do not use MLs, with a difference of 746.3 days. RDHs who used MLs and left the profession was 10.39% opposed to 13.69% who left the profession and did not use MLs.

Medical Cost

The amount of medical costs was calculated by multiplying the total amount of major sick days by $42, which was the average cost of medical visits per major sick day. RDHs who did not wear MLs had a total medical cost of $48,011 over the 20 year

horizon, opposed the RDHs who did wear MLs and had a total medical cost of $38,510 with a difference of $9,501.

Turnover Cost

Turnover cost was calculated by using the variables: RDH hourly wages, creating and placing an ad, reviewing resumes, conducting interviews and reference checks. The data used for the variables was extrapolated from a 2005 study (Talbot,2005). An inflation factor had to be determined for the costs increase from 2005 to 2016. The Consumer Price Index (CPI), taken from the Medical Care Services from the Bureau of Labor and Statistics (BLS), from 2005 was 339.4 and 2016 was 499.2. An inflation factor of 1.47 was calculated from the two years giving a turnover cost of $1099.50. The turnover number was calculated by multiplying the number of RDHs with a major MSD issue every year by the percentage of RDHs who left the profession due to a major MSD episode. That number was then multiplied by the turnover cost of $1099.50 for each year, giving a total turnover cost of $12,073 for RDHS who wore MLs and $15,876 for RDHs who did not wear MLs, with a difference of $3,803.

With Magnification Loupes

Sick Days Minor MSD	Sick Days Major MSD	Salary Cost	Medical Costs	Total Sick Days	Total Cost	Turnover Number	Turnover Cost
60	0	$16,781	$ -	60	$16,781	0	$ -
75	19	$26,290	$798	94	$27,088	0.24	$264
78.9	33.3	$31,375	$1,397	112.2	$80,771	0.42	$462
79.9	41.6	$33,988	$1,748	121.5	$167,736	0.52572	$578
80.0	46.1	$35,264	$1,937	126.1	$274,345	0.582474	$640
79.7	48.4	$35,827	$2,032	128.1	$391,498	0.611134	$672
79.3	49.4	$36,012	$2,076	128.8	$513,954	0.624443	$687
78.9	49.8	$35,998	$2,093	128.7	$638,845	0.62953	$692
78.4	49.9	$35,878	$2,096	128.3	$764,634	0.630255	$693
77.9	49.8	$35,704	$2,090	127.7	$890,505	0.62868	$691
77.4	49.6	$35,501	$2,081	126.9	$1,016,030	0.625899	$688

76.9	49.3	$35,285	$2,070	126.2	$1,140,981	0.622493	$684
76.4	49.0	$35,061	$2,057	125.4	$1,265,244	0.618768	$680
75.9	48.7	$34,835	$2,045	124.6	$1,388,758	0.614889	$676
75.4	48.4	$34,608	$2,031	123.7	$1,511,496	0.610939	$672
74.9	48.1	$34,381	$2,018	122.9	$1,633,443	0.606965	$667
74.4	47.7	$34,155	$2,005	122.1	$1,754,597	0.602991	$663
73.9	47.4	$33,930	$1,992	121.3	$1,874,957	0.599029	$659
73.4	47.1	$33,706	$1,979	120.5	$1,994,526	0.595086	$654
72.9	46.8	$33,484	$1,966	119.7	$2,113,308	0.591164	$650
1519.4	869.3	$296,239	$36,510	2388.7	$19,087,676		$12,073

Without Magnification Loupes

Sick Days Minor MSD	Sick Days Major MSD	Salary Cost	Medical Costs	Total Sick Days	Total Cost	Turnover Number	Turnover Cost
91.2	0	$25,507	$ -	91.2	$25,507	0	$ -
104.5	28.9	$37,308	$1,213	133.4	$38,521	0.3648	$401
106.3	47.5	$43,013	$1,997	153.8	$117,970	0.600461	$660
106.1	57.4	$45,719	$2,412	163.5	$241,182	0.725265	$797
105.4	62.3	$46,901	$2,616	167.7	$387,622	0.786836	$865
104.6	64.5	$47,305	$2,710	169.1	$545,487	0.815035	$896
103.8	65.4	$47,309	$2,746	169.2	$708,535	0.825975	$908
102.9	65.6	$47,111	$2,753	168.4	$873,539	0.828052	$910
102.0	65.4	$46,810	$2,745	167.4	$1,038,840	0.825598	$908
101.1	65.0	$46,458	$2,729	166.1	$1,203,592	0.820843	$903
100.2	64.5	$46,081	$2,710	164.8	$1,367,364	0.814935	$896
99.4	64.0	$45,694	$2,688	163.4	$1,529,942	0.808464	$889
98.5	63.5	$45,302	$2,666	162.0	$1,691,221	0.801734	$882
97.6	62.9	$44,910	$2,643	160.6	$1,851,153	0.7949	$874
96.8	62.4	$44,520	$2,620	159.2	$2,009,719	0.788042	$866
95.9	61.8	$44,132	$2,597	157.8	$2,166,917	0.781201	$859
95.1	61.3	$43,747	$2,575	156.4	$2,322,750	0.774398	$851
94.3	60.8	$43,365	$2,552	155.1	$2,477,225	0.767642	$844
93.5	60.2	$42,986	$2,530	153.7	$2,630,352	0.76094	$837
92.6	59.7	$42,610	$2,508	152.4	$2,782,142	0.754294	$829
1991.9	1143.1	$389,343	$48,011	3135.0	$25,522,132		$15,876

Worker's Compensation

Worker's Compensation (WC) is very rare in the RDH profession. A RDH will not receive WC until he/she has left the professional. The data shows 0.94 RDHs received WC of the ones who wore MLs, and 1.25 received WC of the RDHs who did not wear MLs; with a difference only being third of RDHs who leave the profession are awarded WC. Not statistically significant.

QALY (day)

Quality-adjusted-life-year (QALY) and days is very minimal in this study. The data below shows that the quality of life when affected with a major or minor MSD issue is very minimal. Wearing MLs to prevent a minor or major MSD episode gives a RDH 1998.21 total QALYs, and not wearing MLs gives a RDH a total QALY of 1997.66; with a difference of 0.56 QALY. That data shows that incorporating MLs to prevent a minor or major MSD episode would improve a RDH QALY

With Magnification Loupes

Sick Days Minor MSD	Sick Days Major MSD	Worker's Comp	Worker's Comp Cost	Minor MSD QAL Days	Major MSD QAL Days	Healthy QALYs	Illness QALYs	Total QALYs
60	0	0.0	$ -	48	0	99.84	0.13	99.97
75	19	0.0	$ -	60	11.4	99.74	0.20	99.94
78.9	33.3	0.0	$ 48,000	63.14	20.0	99.69	0.23	99.92
79.9	41.6	0.1	$ 132,000	63.92	25.0	99.67	0.24	99.91
80.0	46.1	0.1	$ 237,144	63.98	27.7	99.65	0.25	99.91
79.7	48.4	0.2	$ 353,639	63.78	29.0	99.65	0.25	99.90
79.3	49.4	0.2	$ 475,866	63.46	29.7	99.65	0.26	99.90
78.9	49.8	0.3	$ 600,754	63.10	29.9	99.65	0.25	99.90
78.4	49.9	0.4	$ 726,660	62.71	29.9	99.65	0.25	99.90
77.9	49.8	0.4	$ 852,711	62.31	29.9	99.65	0.25	99.90
77.4	49.6	0.5	$ 978,447	61.91	29.7	99.65	0.25	99.90
76.9	49.3	0.6	$1,103,627	61.50	29.6	99.65	0.25	99.90
76.4	49.0	0.6	$1,228,125	61.10	29.4	99.66	0.25	99.90

75.9	48.7	0.7	$1,351,879	60.70	29.2	99.66	0.25	99.91
75.4	48.4	0.7	$1,474,857	60.30	29.0	99.66	0.24	99.91
74.9	48.1	0.8	$1,597,045	59.90	28.8	99.66	0.24	99.91
74.4	47.7	0.9	$1,718,438	59.51	28.6	99.67	0.24	99.91
73.9	47.4	0.9	$1,839,036	59.11	28.5	99.67	0.24	99.91
73.4	47.1	1.0	$1,958,842	58.72	28.3	99.67	0.24	99.91
72.9	46.8	1.0	$2,077,859	58.34	28.1	99.67	0.24	99.91
1519.4	869.3	0.9	$18,754,927	1215.50	521.6	1993.46	4.76	1998.21

Without Magnification Loupes

Sick Days Minor MSD	Sick Days Major MSD	Worker's Comp	Worker's Comp Cost	Minor MSD QAL Days	Major MSD QAL Days	Healthy QALYs	Illness QALYs	Total QALYs
91.2	0	0.0	$ -	72.96	0	99.75	0.20	99.95
104.5	28.9	0.0	$ -	83.61	17.3	99.63	0.28	99.91
106.3	47.5	0.0	$72,960	85.01	28.5	99.58	0.31	99.89
106.1	57.4	0.1	$193,052	84.84	34.5	99.55	0.33	99.88
105.4	62.3	0.2	$338,105	84.32	37.4	99.54	0.33	99.87
104.6	64.5	0.2	$495,472	83.69	38.7	99.54	0.34	99.87
103.8	65.4	0.3	$658,479	83.01	39.2	99.54	0.33	99.87
102.9	65.6	0.4	$823,674	82.31	39.3	99.54	0.33	99.87
102.0	65.4	0.5	$989,285	81.61	39.2	99.54	0.33	99.87
101.1	65.0	0.6	$1,154,404	80.90	39.0	99.54	0.33	99.87
100.2	64.5	0.7	$1,318,573	80.20	38.7	99.55	0.33	99.87
99.4	64.0	0.7	$1,481,560	79.50	38.4	99.55	0.32	99.88
98.5	63.5	0.8	$1,643,252	78.81	38.1	99.56	0.32	99.88
97.6	62.9	0.9	$1,803,599	78.12	37.8	99.56	0.32	99.88
96.8	62.4	1.0	$1,962,579	77.44	37.4	99.56	0.31	99.88
95.9	61.8	1.1	$2,210,188	76.76	37.1	99.57	0.31	99.88
95.1	61.3	1.1	$2,276,428	76.09	36.8	99.57	0.31	99.88
94.3	60.8	1.2	$2,431,307	75.42	36.5	99.58	0.31	99.88
93.5	60.2	1.3	$2,584,836	74.76	36.1	99.58	0.30	99.88
92.6	59.7	1.4	$2,737,024	74.11	35.8	99.58	0.30	99.88
1991.9	1143.1	1.25	$25,084,778	1593.48	685.9	1991.41	6.24	1997.66

Research Question

Is there a financial impact on RDHs and dental practices when implementing magnification loupes during a RDH's training as opposed to not utilizing loupes at all?

Presentation of the findings

The results are measurable and show significant financial gains for a RDH using magnification loupes over a 20 year period. The cost of magnification loupes are minimal in comparison to the over $6 million gain during a 20 year time period. A RDH can expect to have a savings of $3,094 annually if he or she decides to utilize loupes early in his or her career.

Results over 20 years	**Loupes**	**No Loupes**	**Difference**
Total Loupes cost	$ 250,600		
Total Salary, WC medical care	$ 19,087,676	$ 25,522,132	
Grand Total Cost	$ 19,338,276	$ 25,522,132	$ 6,183,856
Total Sick Days	2388.7	3135.0	746.3
Total Leaving DH	10.39	13.69	3.30
Total WC cases	0.94	1.25	0.32
Turnover cost	$ 12,073	$ 15,876	$ 3,803
Total QALYS	1998.21	1997.66	0.56
Total with Turnover			$ 6,187,659
Cost differences per Individual over career			$ 61,877
Annual cost differences per individual			$ 3,094

EVIDENCE TABLE Focused Question: What is the prevalence of the progression of musculoskeletal problems?

Author/Year	Purpose of Study	Study Design/Subjects	Sample & Set	Outcome Measures	Design Limitations
Ng et al/2016	**The study examined the prevalence of MSD and conduct postural assessments of oral health and dental students**	**Design: Convenience Sample, Cross-sectional Subjects: Students in their 1st and final year of BOH and DDS programs**	**136 students completed the MSD survey and 138 students consented to having their posture assessed. Students were from the University of Melbourne, Australia**	**The study suggests a link between dental and oral health students and MSD, which is on par the MSD of professional oral health personnel**	**Inconsistency between surveys**
Liss et al/1995	**The study examined whether dental hygienists were at risks for carpal tunnel and other musculoskeletal problems**	**Design: Convenience Sample Cross-sectional Subjects: Dental hygienists and dental assistants**	**The Standardized Nordic Questionnaire was sent to all members of the Ontario Dental Hygienists' Association**	**The study suggests an important burden of musculoskeletal problems attributed to the dental hygienist's work environment**	**Moderate response rate of 50% Only symptoms were considered**
Al-Mohrej et al/2016	**The study examined the prevalence of musculoskeletal pain in dental practitioners**	**Design: Survey, Random cluster sampling, Cross-sectional Subjects:**	**Survey distributed among dental practitioners in Riyadh, Saudi Arabia**	**The study suggests that there is a high prevalence of musculoskeletal pain among older and female**	**Inconsistent findings concerning the effect of number of years work**

				dental practitioners	
Morse et al/2007	**The study examined self-reported and physician diagnosed neck and shoulder pain**	**Design: Longitudinal multi-cohort study, 40-page questionnaire** **Subjects: 94 experienced dental hygienists, 27 dental hygiene students, 39 dental hygiene students who were dental assistants**	**400 dental hygienists were randomly selected from the Connecticut licensure list (92 woman and 2 men consented), hygiene students were orally recruited by faculty at each of the 3 dental hygiene programs in Connecticut**	**The study found that risk of neck and shoulder disorders increases with a background in dental assisting and the risk musculoskeletal symptoms have serious implications for career loss, disability, and productivity for dental hygienists.**	**Low response rate experienced dental hygienists** **Follow up of graduated students**

Chapter 5

Discussion

MSDs are prevalent in the dental profession, and the loss of income to dental professionals due to MSD pain is greater than $41 million per year (Oberg,1993). MSD amongst dental professionals is attributed to many factors such as: poor ergonomics, long clinical hours and repetitive motion causes (Liss,1995). MLs minimize poor ergonomics by reducing the time spent in awkward postures (Ng,2016). MLs are cost-effective, costing as little as $125 per year over a 20 year career, compared to MSD injuries which are significantly more costly (Syme,1997). Research studies that are related to MSD and MLs usually focus on the posture and ergonomic using qualitative measures. This study estimated the expected financial impact on RDHs and on dental practices using a Markov Model and spreadsheet to integrate information from the literature into estimates than can be used to inform discussions about requiring the use of loupes in RDH training. The Markov Model shows: the cost of ML purchase to a student and the expected cost avoided over 20 years after graduation; the cost to a dental practice of purchasing and fitting MLs for a RDH and cost of sick days and potential practice disruption due to DH turnover and/or reduced productivity avoided due to ML usage by a RDH.

Hypothesis one. Results demonstrate significant findings of RDH who develop MSD and progress through the 4 different states of: no problem, minor problem, major problem and leaving the dental hygiene profession. The interesting results of this study show that by year 20, 62.8% of DHs will have no problem with MSD, 24.3% will suffer from a minor problem, 2.46% will have a major problem and 10.39% will end up leaving

the dental hygiene profession. The data suggest that by year 20 a DH, who consistently practices in a clinical setting, will have a 10.39% chance of leaving the profession due to MSD.

Hypothesis two. The average cost of magnification loupes is around $1706 with battery replacement for the light being $120 every three years. Many distributors have a lifetime warranty on their magnification loupes, which protects against normal wear (rdh.com,2017). The data shows that for the population size of 100, the total cost of magnification loupes is $250,600. The Markov Model calculated the total cost of: salary not received due to missed work due to a minor or major MSD issue, total cost of medical expenses due to a MSD episode and worker's compensation cost. When comparing the two Markov Models (with MLs and without MLs), the data shows the total cost for a RDH with MLs calculates to $19,338,276 and the total cost for a RDH without MLs is $25,522,132, with a difference of $6,183,856. The loss of income to dental practitioners due to MSD pain (missed work days) was greater than $41 million per year (Oberg,1993). The data shows a significant measurable difference in the cost of a RDH wearing magnification loupes, opposed to a RDH not wearing magnification loupes over a 20 year period.

Hypothesis three. Employee turnover costs organizations money through loss in production, and through rehiring and training expenses (Loiacono,1989). Dental offices also deal with the cost of replacing a RDH who is unable to return to work do to MSD, whether it be short term, long term or permanently. There are several factors and cost that go into the dental practice disruption due to a RDH missing from or leaving the practice. The data shows that there is a statistically significant difference in sick days, RDHs

leaving the profession and turnover costs between RDHs who wear MLs and those that do not wear MLs. Over a RDH's career, she/he can save $61,877 by utilizing MLs.

Conclusion

For the purpose of this study, the Markov Model was very useful in extrapolating data from the literature to show the financial impact MLs have on MSD, the RDH and the dental practice. The study reveals that RDHs who wear MLs gain a statistically significant cost savings over a 20 year period. The quantitative measures in this study should be used to explore a mandatory implementation of MLs for students in dental hygiene programs. This study was limited to published data; when the literature was missing the data needed, reasoned assumptions were made that could be tested in a sensitivity analysis. Further research can be done to see how MLs can be included into RDH students' tuition to ease the initial cost of MLs.

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